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ABSTRACT

Addressed to the business education teacher, this guide is intended to provide appropriate information, viewpoints, and attitudes regarding the metric system and to make suggestions regarding presentation of the material in the classroom. An introductory section on teaching suggestions emphasizes the need for a "think metric" approach made up of hands-on experience with the use of convenient referents (models for some of the commonly used units) but very little conversion between the metric system and the customary system. Major contents are in eight chapters: (1) The System, (2) Lengths, (3) Area, (4) Volume (Cubic Measure and Liter Measure), (5) Mass, (6) Volume-Mass, (7) Other Units (Temperature, Force, Energy-Work, Power, Pressure-Stress, and Torque), and (8) Miscellaneous Exercises. Each chapter includes explanatory material and a variety of suggested learning activities, some with directions addressed to the student. Some activities and exercises are of a general nature and some are related to specific occupational areas: distributive marketing, secretarial, keypunch operators, and clerical. A bibliography and answers to the exercises are appended. (JT)

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METRIC IMPLEMENTATION GUIDE

IMPLEMENTING THE METRIC SYSTEM

IN

BUSINESS OCCUPATIONS

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F O R E W O R D

This book is intended to guide vocational-technical educators in the implementation of the metric system in the classroom. It is not an official or complete presentation and discussion of the system. Indeed, only a small portion of the metric system is appropriate for discussion in this document and for vocational-technical instruction. Books and documents are available which do present the official position for the use of the metric system in its entirety.

Through the years there have been many systems of measure labeled "the metric system," so it is important to understand which such system is meant when the term metric system is used. The U. S. Metric Conversion Act of 1975 declared that the system to be followed was the International System of Units as established by the General Conference of Weights and Measures in 1960, otherwise known as SI (Systeme Internationale). It is the SI to which professional, industrial and educational associations, governmental and educational agencies, and business enterprises are now converting.

In most countries of the world some segment of the society has used a metric system. It is likely, however, that at least some elements of that system do not conform to the SI. For example, in this country metric units have been used in the sciences and taught in science classes for years, but in large part they have been cgs (centimeter, gram, second) units, whereas the SI is a mks (meter, kilogram, second) system. This means that the dyne and other units in the cgs system are not accepted for use in the SI. The quintal (100 kilograms), used in Europe and somewhat in the U. S., is metric but is

not acceptable for use in the SI. The micron (0.001 millimeter) is another example of a metric unit which is not an SI unit. The U. S. Government has formed a committee to guide in the conversion from the traditional system to the SI but it may be some time before certain practices and policies are agreed upon and adopted large-scale in this country.

In this book attention is focused primarily on SI. Secondarily, attention is given to other metric units and customary units, and their relationship to SI.

ACKNOWLEDGMENTS

One of the functions of the Mathematics Department of Illinois State University is to engage in projects which will improve the effectiveness of elementary, secondary and post-secondary, and teacher education programs. Another function is to serve the citizens of the State of Illinois. Both functions are combined in the preparation of this Metric Implementation Guide, for the guide should ease the transition to the metric system (SI) of measurement for students and those employed in business occupations.

Measurement is a mathematical topic, but its use in the business occupations is best known by practitioners and educators in that field. The authors are deeply grateful to Wilma Alexander, James Brubeck, John Rich, Daniel Swanson and Dick Tharp for their assistance in gathering information for publication. Sincere thanks are extended to Sylvia Banks, Densie Crissey and Warren Perry for their helpful examination of drafts of this guide.

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IMPLEMENTING THE METRIC SYSTEM IN BUSINESS OCCUPATIONS

Measurement practices in the business occupations are changing. The change will be felt in all business occupations but the areas affected immediately are sales and distribution.

Many products now have the amount of the contents identified by a customary (English) unit and also a metric unit. A can of baked beans is labeled one pound and also 453.6 grams; a can of paint is labeled one quart and also 0.956 liter. Soon the primary unit will be metric and the secondary unit will be customary. Other products are metric only--soft drink bottles for example. Some domestic and foreign automobile engine sizes are given in liters or cubic centimeters.

There is some indication that clothing sizes will be expressed in centimeters. A man's shirt presently sized 15½ may become size 39 (39 cm). Shoes may be sized according to the length and width of the foot. The size 280/90 would fit a foot 280 millimeters long and 90 millimeters wide. Some metric units are presently marked on pattern instruction sheets, pattern books and pattern pieces. The pattern industry will begin to supply all of the needed information in metric units rather than in the customary units. Fabrics will be sold by the meter and the width will be expressed in centimeters. Fabric widths may be changed slightly so they can be expressed in whole numbers. Carpeting, floor coverings, and wall coverings may be sold in widths which are multiples of a meter.

It will not be long before the impact of the changeover to metric will be felt in all business occupation areas. It is therefore appropriate and important to prepare the present students for this development regardless of when it may appear.

Teaching Suggestions

The primary goal in teaching the metric system is--think metric. All of the activities and instructional procedures should be designed with that goal in mind. Teaching activities which are primarily lecture or teacher-focused, therefore, are inadvisable. Activities which emphasize measuring, estimating and thinking in the system are far more valuable. Filmstrips and overhead transparencies, commercially produced or otherwise, are of limited value. In fact, few of these filmstrips and transparency packets are without serious error and most are quite expensive. Worse, however, is that the use of these materials is deficient in the same way that lectures are deficient--the student is only a passive participant.

Hands-on Experience

The main emphasis of the instruction should be on experiences in actually measuring, estimating and thinking metric. For example, after students become acquainted with the meter and its subunits (particularly decimeter, centimeter and millimeter) they might use a meter tape to answer such questions as the following:

How many meters long is the room?

The window pane is how many centimeters wide?

What are the centimeter dimensions of the face plate on the light switch?

Unsharpened pencil lead is how many millimeters thick?

For some initial measurement activities both the object to be measured and the unit to be used should be selected by the teacher. Measurements should be reported to the nearest <u>whole</u> unit.

After some time has been spent with these measurement activities, activities in estimating lengths of various objects should be provided. The

objects to be measured and the units to be used should be varied. The emphasis should be "estimate, then check by measuring." Care should be taken to avoid precise measurements in checking. The goal is not great skill in estimating and measuring; the goal is think metric--internalize the units.

Convenient Referents

Students should look for convenient models for some of the commonly used units. It might be, for example, that the width of the nail on their little finger is about 1 cm, the distance across the back of their hand is 1 dm, or the top of their hipbone is about 1 m above floor level. Objects commonly carried in pocket or purse may provide convenient models.

The purpose of such an approach is to promote thinking metric on the part of students who have grown up learning to think in and to use the English system and who must now, in a short period of time, change and begin to think metric. Precise measurements and accurate estimates are not especially important. What is important is that the students quickly build in a set of referents which will enable them to make judgments about measurements of other objects as well as to internalize the metric system. This approach should be applied to the teaching of area, volume and mass as well.

Little Conversion

Conversions between the metric system and the customary system should be avoided while learning the metric system. Conversions between systems can be made, when necessary, by simply consulting a table of equivalents readily available and doing the necessary multiplication or division. This is something which needs little instruction. It is appropriate, however, to make a few rough basic comparisons such as between the meter and the yard, the liter and the quart, and so on.

Conversions within the metric system, on the other hand, are quite a different matter. Converting from one metric unit to another is easily done by simply multiplying or dividing by a power of 10; a very simple task compared to converting in the customary system. Perhaps because it is so easy there is a tendency for teachers to overemphasize this activity. Some practice with conversions in the metric system is appropriate but practicing mechanical shortcuts is of questionable value. Instead, it seems more appropriate and beneficial to reason from the basic relationships between the units. Consider the following:

a. 750 grams = _____ kilogram(s)

The reasoning could be:

We have 750 grams and it takes 1000 grams to make a kilogram, so we have only 0.750 kilogram.

b. How many milliliters does a 3 liter container hold?

The reasoning might be:

The container holds 3 liters, and since 1 liter is 1000 milliliters the container holds 3000 milliliters.

Secretarial Practices

Instruction in typing classes needs to change very little with the advent of the metric system. It is unlikely that any significant modification will be made to the typewriter itself; i.e., there probably will be no "metric typewriter." There may be new paper and envelope sizes but it is too early to tell what the sizes will be. A simple but significant change will aid typing students to adapt easily to any developments: omit the word inch from typing instruction.

Eliminating the use of the inch and working in terms of lines and spaces instead will allow students to learn the principles of setting up letters, manuscripts, and addressing which will apply regardless of the measurement

system in use. Line lengths may be described as 40-, 50-, or 60-space lines. Instructions such as "Type the date on line 12 and the inside address 2 lines below the date." or "When addressing an envelope begin on a line just below the vertical center and just to the left of the horizontal center." may be used. Margins may be stated as 12 (16) spaces or 6 lines. Such terminology will establish typing practices which are just as efficient as those involving units of measure.

If, however, the instructor does wish to use metric measures in stipulating margin width, etc., "exact" conversions from the customary measures should be avoided. It would be better to specify a margin of 3 centimeters rather than 2.5 centimeters or 4 centimeters rather than 3.75 centimeters.

Shorthand forms for metric units have been discussed in recent literature. Standard metric symbols like cm, kg, N·m, and km/h are made quickly and might be used instead of the shorthand forms. For correct transcription students must know the correct SI symbols, unit names, and practices, whether the transcription be from shorthand forms or from SI symbols. Time given in shorthand and notehand classes to understand metric units and practices will be well spent.

Use of This Guide

This guide is addressed to the teacher. Its aim is to provide appropriate information, viewpoints, and attitudes regarding the metric system and to make suggestions regarding the presentation of the material in the classroom. A variety of activities is given and the directions for some of these activities are addressed to the student. Nevertheless, it is not intended to be a workbook for students, nor is it intended that the activities given are sufficient or comprehensive. The attempt has been to provide examples of suitable activities designed to help the students think metric.

Several types of activities are suggested in each section. Each of these types makes a unique contribution to the learning process. It is appropriate, then, that some of each type should be provided for the student as each section is developed.

I. Measure

e.g., p. 14, exercise 1

II. Estimate and Measure

e.g., p. 26, exercise 2

III. Reasonable ("ball park") Estimates

The diameter of an aspirin tablet is _____.

(a) 3 m (b) 1 cm (c) 15 mm

IV. Metric Conversion Drill

1450 g = _____ kg

V. Applications

This guide is addressed to business occupational programs including Distributive Marketing, Secretarial, Keypunch Operators, and Clerical. Some of the activities and exercises included are of a general nature and some are related to specific occupations. It is intended that the teacher will select

from the items suggested those which are appropriate to the group of students involved and it is expected that the suggested activities will stimulate the creation of additional or more appropriate activities by the teacher.

It must be emphasized again that the actual measurements of some of the items given are not important. What is important is that the students have the opportunity to actively estimate and measure many objects with which they have frequent contact; that they be encouraged to "think metric."

The System

The metric system had its beginning in the latter part of the 18th century when a group of French scientists, commissioned by their government, developed a system of measurement units. The system was officially adopted by the French government in 1795, and in 1840 its use was made mandatory by the government. Over the years most of the countries of the world, including the United States, have adopted it. In 1866 the U. S. Congress passed an act making it legal but not mandatory to use the metric system in the United States. The Eleventh General Conference on Weights and Measures, meeting in 1960, adopted the International System of Units (SI)--the universally recognized metric system today. In December, 1975, HR 8674 was signed into law by President Ford, a bill that provides for the establishment of a 17-member metric board that will coordinate voluntary conversion to the SI in the U. S.

The SI is a modernized metric system of measurement with features which make it superior to the U. S. customary system and to other metric systems. One feature is that the base of the system is <u>absolute</u>; that is, force is not defined by action of gravity. An absolute system makes for simplicity of calculation. In SI units, a force of one newton gives a mass of one kilogram an acceleration of one meter per second per second. By contrast, in the European system, a force of one kilogram-force accelerates a mass of one kilogram 9.806 650 meters per second per second, and in the U. S. customary system, one pound-force accelerates a mass of one slug 32.174 feet per second per second. Another feature is <u>coherence</u>. In a coherent system any derived unit is related to any other, or to the base units, without the use of conversion factors. A third feature is that only <u>one unit</u> is used for each physical quantity. By contrast, the customary system has nine commonly used units for area, 25 units for energy, and 26 units for length.

The SI consists of seven base units, two supplementary units, and derived units, some of which have been given special names.

Base Units

Unit	Quantity	SI Symbol
meter	length	m
kilogram	mass	kg
kelvin	temperature	K
ampere	electric current	A
mole	molecular substance	mol
second	time	s
candela	light intensity	cd

The derived units are determined by multiplying or dividing base units, without using numerical factors other than one. Some of these are shown below. For a more complete listing of these units see Appendix A or a source from Appendix C.

Some Derived Units Without Special Names

Unit	Quantity	Formula
square meter	area	m^2
cubic meter	volume	m^3
meter per second	linear velocity	m/s
kilogram per cubic meter	density	kg/m^3

Some Derived Units With Special Names

Unit	Quantity	SI Symbol	Formula
newton	force	N	$m \cdot kg \cdot s^{-2}$
pascal	pressure	Pa	N/m^2
watt	power	W	J/s
joule	energy	J	N·m
coulomb	electric charge	C	A·s
volt	electric potential	V	W/A
hertz	frequency	Hz	1/s or s^{-1}
ohm	electric resistance	Ω	V/A
farad	electric capitance	F	C/V

Multiples and submultiples of these units are expressed by means of certain prefixes.* Some of the prefixes are:

Prefix	Meaning	SI Symbol
mega	1 000 000	M
kilo	1 000	k
hecto	100	h
deka	10	da
deci	0.1	d
centi	0.01	c
milli	0.001	m
micro	0.000 001	μ

*For a more complete listing of the prefixes, see Appendix A.

The prefixes have decimal meanings, i.e., each is a power of ten, and conversions among the units is facilitated by a knowledge of our numeration system.

Examples

1 hectogram	= 100 grams	(1 hg = 100 g)
1 centimeter	= 0.01 meter	(1 cm = 0.01 m)
1000 grams	= 1 kilogram	(1000 g = 1 kg)
1 meter	= 10 decimeters	(1 m = 10 dm)
1 deciliter	= 0.1 liter	(1 dL = 0.1 L)*

Not all the prefixes will be used in actual practice. Note that the SI symbol for a unit is used for both the singular and plural forms. Other established conventions for spelling, usage, etc., include:

1. Symbols for unit names are written in lower case unless they are derived from proper names. Most SI symbols for unit names are single letters (for some exceptions see Appendix A).

   RIGHT: Contents 454 g
   WRONG: Contents 454 GM

2. Periods are not used after the symbols or prefixes unless a sentence ends with such.

   RIGHT: The pencil is 16 cm long.
   WRONG: The pencil is 16 cm. long.

3. A zero digit is used in the units place when naming a number less than 1.

   RIGHT: The distance to the next road is 0.8 km.
   WRONG: The distance to the next road is .8 km.

---

*The symbol for liter as prescribed in the SI is "ℓ". In December, 1976, however, the National Bureau of Standards stated that the capital letter "L" will be used instead in the U. S. This symbol has several advantages over the "ℓ" and has been urged for adoption in the SI.

4. Numerals containing more than four digits should be separated into groups of three digits in order to facilitate reading. No commas should be used in the spaces between groups of digits.

RIGHT: The distance from the earth to the moon is about 385 000 km.
WRONG: The distance from the earth to the moon is about 385,000 km.

RIGHT: A microgram is equal to 0.000 001 g.
WRONG: A microgram is equal to 0.000001 g.

5. Prefixes are not to be used without a unit.

RIGHT: The weight lifted was 186 kilograms.
WRONG: The weight lifted was 186 kilos.

Additional information and discussion of the metric system may be found in a number of current sources (Appendix C).

Length

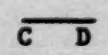
In the business occupations the metric system has been little used in the measurement of length. This means that as the country shifts to the metric system there will be substantial impact on personnel in the business occupations, but it also means that there is now a great opportunity—the opportunity to develop nationwide and worldwide standards for a variety of items. Suitable standards and measurement units are being discussed in many different areas and there are many decisions to be made about standards for items encountered in the business occupations. Many national committees representing various sectors of our economy, industry, and labor are studying these problems. At the present time, however, very little hard conversion has taken place.

In the metric system (SI) the basic unit of length is the meter—probably the most familiar of the metric units. The meter is a little longer than the yard. Other metric units of length which are frequently used are:

kilometer—about 0.6 mile (or 7 city blocks) — 1 km = 1000 m

decimeter—the length of segment AB — 1 dm = 0.1 m

centimeter—the length of segment CD — 1 cm = 0.01 m



millimeter—the length of the segment to the right — 1 mm = 0.001 m

Suggested Activities*

1. Find several objects which have approximately the lengths in the chart below. Try to find things which you can easily remember or that you are frequently near. Include body measurements such as palm width, length of a finger, distance from hip to floor, etc.

1 m	1 dm	1 cm	1 mm

*The activities suggested in this book are meant to include several areas in the business occupations. The teacher may select from these activities those most appropriate to the subject and the students being taught. Because students in sales and distribution do encounter many products with either dual units or strictly metric units, exercises involving a variety of products are also included.

2. Use the objects listed below and others from your school or home to practice linear measurement. The main objective is to develop a better "feel" for metric units of length, and therefore rough estimates and measures are adequate. Some objects you are near frequently; the measures of these (typing table height, for example) you will want to remember. More than one dimension of some objects may be estimated. Check your estimates by measuring.

Object	Estimated Length	Measured Length
Space bar on a typewriter		
Pane of glass		
Dollar bill		
Display manikin		
Platen		
Newspaper advertisement		
Paper clip		
Floor tile		
New pencil		
Typing table		
Hand truck		
Index card		
Packing carton		
Key punch card		
Piece of chalk		
Classroom		
Paper-bail roller		
Pencil lead		

The purpose in all these activities is to help foster "thinking metric." Accuracy in estimating is not crucial. Discourage students from measuring too precisely here.

3. Draw a line segment that has length

(a) 1 dm (b) 5 cm (c) 3 mm (d) 15 cm (e) 20 cm

Check by measuring. Try again with some other lengths until you are satisfied with your estimating skill.

A feel for metric units is important. Practice with estimating helps to think metric. Exercises such as the following also help. They will be of little value, however, if students do them by conversion. Instead, they should be done by just considering what is a reasonable answer. The measures given in exercises 4 and 5 and in similar exercises later in the unit are not important. Students may not know these measures nor do they need to in order to answer the questions. They should be able to rule out the inappropriate units or measures just by a general familiarity with the objects involved.

4. Supply the appropriate unit to make the sentence reasonable. Choose from mm, cm, dm, m, or km.

   a. The heading of the second page for a two-page letter is started about 25 _____ from the top of the page.

   b. One standard size index card is about 12.5 _____ long.

   c. The main aisles in a discount store are usually at least 21 _____ wide.

   d. The space bar on a certain typewriter is about 18.5 _____ long.

   e. The classroom is about 7 _____ long and 5 _____ wide.

   f. A certain business size envelope is about 24 _____ long.

   g. The thickness of a dime is 1 _____.

   h. The distance from Chicago to St. Louis is 480 _____.

   i. Transparent tape is available in rolls 19 _____ wide and 32.9 _____ long.

5. Choose the best answer from those provided.

   a. A government report is usually single-spaced with _____ margins on all sides.

      (1) 20 mm (2) 2.5 cm (3) 1 dm

b. The average height of the adult female is approximately _____.

(1) 1.4 m (2) 40 dm (3) 650 cm

c. A common neck size for men's dress shirts is _____.

(1) 20 mm (2) 0.5 m (3) 38 cm

d. One standard paper size may be _____.

(1) 210 by 297 mm (2) 210 by 297 cm (3) 2.10 by 2.97 cm

e. The distance from New York to Los Angeles is _____.

(1) 5000 m (2) 5000 km (3) 3000 km

f. On a key punch card are rows of numerals: ones, twos, threes, etc. The height of each of these numerals is about _____.

(1) 0.2 m (2) 2 mm (3) 0.2 mm

g. A railroad boxcar has an interior width of _____.

(1) 1.4 m (2) 4 m (3) 2.8 m

h. Diameters of mechanical pencil lead vary in the _____ range.

(1) 0.3-0.9 mm (2) 3-9 mm (3) 3-9 cm

Converting between metric measures is a needed skill. It is much easier than in the customary system (yards to inches, etc.), so there is some danger of overemphasizing this activity or of emphasizing mechanical procedures. Conversions among mm, cm, dm, m and km are all that are required. Knowledge of a few basic relations of a decimal nature is sufficient for this.

10 mm = 1 cm	10 dm = 1 m	1000 mm = 1 m
10 cm = 1 dm	1000 m = 1 km	100 cm = 1 m

For example, since 1 dm = 10 cm

$$8.6 \text{ dm} = (8.6 \times 10) \text{ cm} = 86 \text{ cm}.$$

Likewise, since 1 dm = 100 mm

$$8.6 \text{ dm} = (8.6 \times 100) \text{ mm} = 860 \text{ mm}.$$

6. Complete the following:

a. _____ mm = 56 dm

b. 56 dm = _____ m

c. _____ m = 3.2 km

d. 28 cm = _____ mm

e. 28 cm = _____ m

f. 8000 m = _____ km

g. 6 m 3 dm 5 cm = _____ m = _____ cm

h. 5 cm 8 mm = _____ cm = _____ m

For "fun":

i. _____ in. = 3 yd. 2 ft. 7 in.

j. 2 yd. 1 ft. 5 in. = _____ yd. = _____ in.

7. An ad is being prepared to be run in a newspaper. If the newspaper charges $2.40 per column-centimeter, what is the cost of a 10 cm ad two columns wide?

8. Equipment is sometimes stored on wooden pallets. Convenient dimensions for pallets used for shipping are 120 _____ by 100 _____.

9. A customer buys 2.9 meters of a certain material priced at $4.75 per meter. Figure the amount of the sale, including 5% sales tax.

Area

Area measurement using metric units seldom occurs at present in the business occupations and may be used only occasionally in physical distribution. Nevertheless, the concept is important for everyone and an understanding of area in metric terms is an aid to understanding volume, pressure, work, and other concepts. The initial activities here as elsewhere are designed to help think metric.

Suggested Activities

A unit of area convenient in many instances is the square centimeter: . "Square centimeter" is expressed with the symbol cm^2.

1. Make a model of a square centimeter from paper.
2. Use your model to estimate the area of each of these regions.

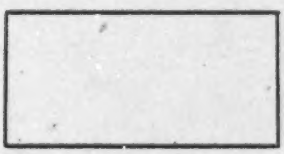


Figure 1

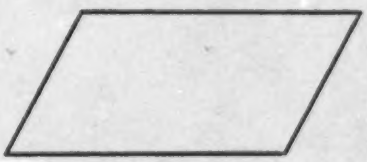


Figure 2

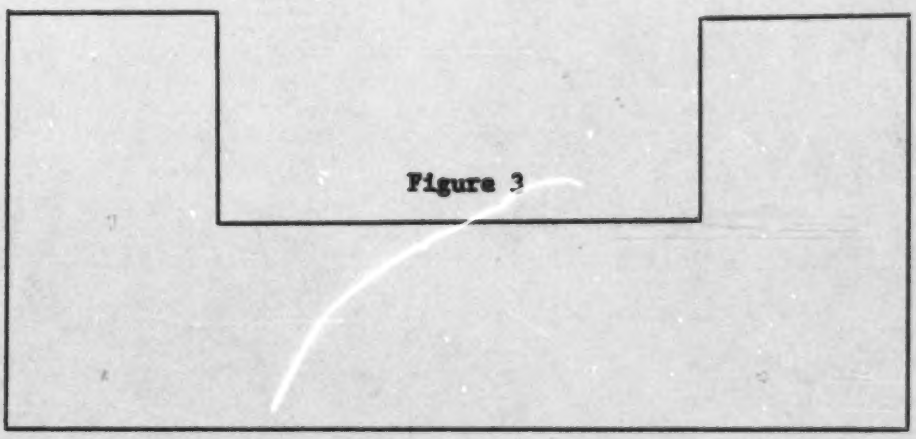


Figure 3

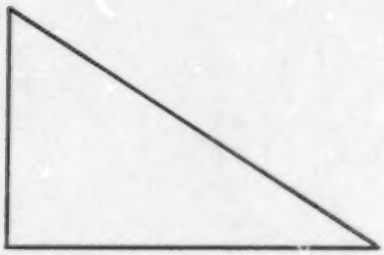


Figure 4

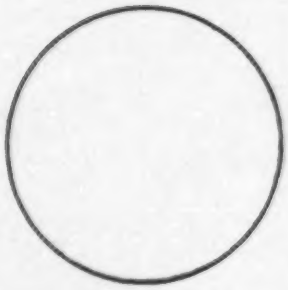


Figure 5

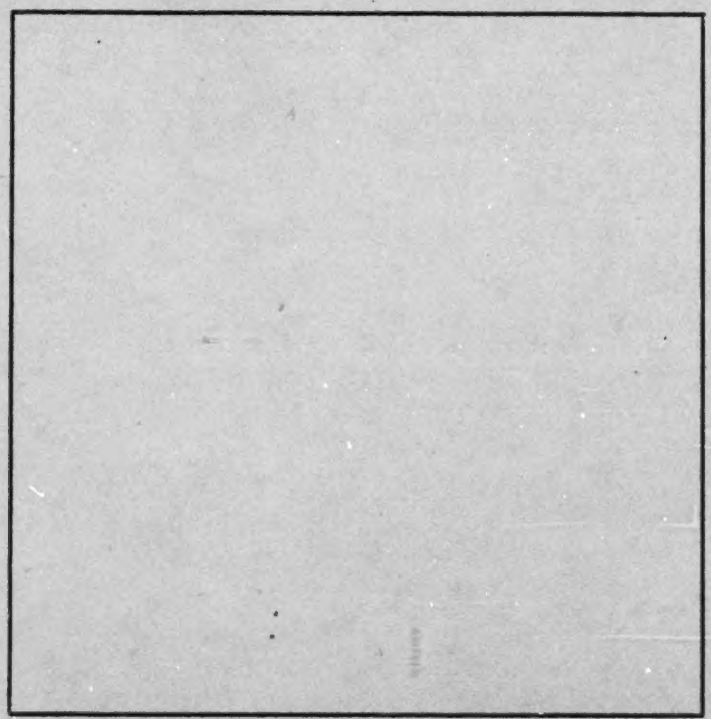
Region	Estimated Area
1	_____
2	_____
3	_____
4	_____
5	_____

The area of a rectangular region is, of course, computed by the formula $A = lw$. For example, a rectangle 2 m by 3 m has an area of 6 square meters (6 m^2); a rectangle 2 cm by 3 cm has an area of 6 cm^2; a large room 8 m by 10.5 m has an area of 84 m^2. Formulas for the area of a triangle and circle are $A = \frac{1}{2}bh$ and $A = \pi r^2$.

3. Check your estimates in number 2 by using your ruler to measure any segments needed to calculate the area.

Region	Calculated Area
1	_____
2	_____
3	_____
4	_____
5	_____

Another convenient unit of area is the square decimeter (dm^2).



4. Make a model of this square unit from heavy paper. Use your model as an aid to estimate the area of several objects. Check your estimate by measuring and calculating. Some objects are suggested; include others from your classroom, home, or place of work.

Object	Estimated Area	Calculated Area
File cabinet		
Packing carton		
Desk top		
Accounting journal cover		
Window pane		
Floor tile		
Typing table		
Display case		
Key punch card		
Doorway		

5. A square meter is a rather large unit of area. What objects can you find in your classroom that have an area of approximately:

a. 2 m^2 _____ _____

b. 4 m^2 _____ _____

c. 0.5 m^2 _____ _____

6. Supply the appropriate unit to make the sentence reasonable. Choose from cm^2, dm^2, or m^2.

a. The area of a postage stamp is about 3 _____.

b. This sheet of paper has an approximate area of 616 _____.

c. The floor of the classroom is about 38.5 _____ in area.

d. Square ceiling tile have an area of about 930 _____.

e. The area of an index card is about 150 _____.

f. A full-page newspaper ad may have an area of 2200 _____.

7. Calculate the area of these rectangular regions:

a. 4 m x 5 m

b. 6 cm x 8 cm

c. 3.6 m x 8 m

d. 27.5 m x 7.6 m

e. 350 m x 500 m

f. 285 m x 312 m

8. Using the given dimensions for a rectangular region find the area in cm^2.

a. 4 m x 18.5 cm

b. 2 m x 3 m

c. 2.5 m x 4.2 cm

d. 22 cm x 28 cm

Find the area in m^2.

e. 420 cm x 5 m

f. 118 cm x 25 cm

g. 65 cm x 6.25 m

h. 0.5 m x 120 m

Sometimes a larger unit of area is convenient. The SI permits the use of hectare (ha) as a unit for measuring large land or water areas. 1 hectare = 10 000 m^2, so a plot 200 m by 300 m has an area of 6 ha.

9. A football field is about 49 m by 100 m (including one end zone). It has an area of about _____ m^2. Two football fields have an area of about _____ m^2. One hectare is 10 000 m^2, so two football fields have a combined area of approximately 1 hectare.

10. Find the area in hectares.

a. 60 m x 75 m

b. 150 000 m^2

c. 100 m x 100 m

d. 20 m x 1 km

A square 100 cm on each side is the same size as a square 1 m on each side. Such a square would contain 100 rows of 100 cm^2 each. Consequently 1 m^2 = 10 000 cm^2.

11. Complete the following.

a. 3 m^2 = _____ cm^2

b. _____ m^2 = 5000 cm^2

c. 5 dm^2 = _____ cm^2

d. 250 cm^2 = _____ dm^2

e. 40 000 cm^2 = _____ m^2

f. 5 cm^2 = _____ mm^2

12. A table top 120 cm by 300 cm has an area of 36 000 cm^2 or _____ m^2.

13. Each of the 5 shelves in a metal storage cabinet is 6 dm wide and 9 dm long. The total storage area of these shelves is _____ dm^2 or _____ m^2.

14. Find the area of a floor in square yards which measures 7 ft. 7 in. by 5 ft. 6 in.

15. Find the area of a floor in square meters which measures 231 cm by 167 cm.

16. How many 10 cm by 10 cm ceramic tiles are needed to cover three walls around a bathtub if two walls are 0.75 m by 2 m and the third wall is 1.5 m by 2 m?

17. Choose the best response from the ones provided.

a. The front page of a daily newspaper has an area of about _____.

(1) 22 m^2 (2) 2200 cm^2 (3) 2.2 dm^2

b. A small exhibit space in a state fair exhibition building might have an area of _____.

(1) 22 m^2 (2) 0.25 km^2 (3) 15 m^2

c. It may take a plate glass _____ in area to replace the broken display window in the jewelry store.

(1) 5 m^2 (2) 2500 cm^2 (3) 2.25 dm^2

d. _____ of corrugated cardboard was used in making a shipping carton for an electric portable typewriter.

(1) 200 000 cm^2 (2) 5.71 m^2 (3) 6700 cm^2

Volume

Measures of volume will be encountered frequently in different areas of life and occasionally in business occupations. In the customary (English) system many different units are used--bushel, peck, quart, gallon, ounce, teaspoon, tablespoon, cup--some for dry measure, some for liquid measure. Cubic units such as the cubic inch and cubic foot are also used to express volume. In the metric system, however, there are only two ways to express volume: in cubic units and in liters.

Cubic Measure

The cubic meter (m^3), cubic decimeter (dm^3) and cubic centimeter (cm^3) will be the commonly used cubic units. Presently it is common to see or hear "cc" used to represent "cubic centimeter." This has been the case with medicines for some time. It is also used in describing engine size for motor bikes and for automobiles--60 cc, 100 cc, 750 cc, 1500 cc, etc. The proper SI symbol, however, is cm^3.

The cubic meter will be used to describe the volume of rooms or buildings. The cubic decimeter may not be used often but it plays an important role in relationships among other metric units which will be discussed later.

The formula for the volume of a rectangular solid is $V = lwh$. The formula for the volume of a cylinder is $V = \pi r^2 h$. In these cases and in others where the volume can be computed by formula, cubic units will be used to express the volume. In many other cases the liter (discussed later) will be used.

Suggested Activities

1. a. Make a model of a cubic centimeter and cubic decimeter out of heavy paper. A suggested diagram is given in Appendix B. (Metal or wood is suitable, also.)

   b. Make a model of a cubic meter using meter sticks or similar material for edges.

   c. Challenge. Make a model of a cubic millimeter.

2. Estimate the volume of several objects in the room by thinking of cubic units—m^3, dm^3, or cm^3. Check your estimates by measuring with the cubic unit or a tape. Some objects are suggested; include others from your room, your home, or your place of work.

Object	Estimated Volume	Measured Volume
Teacher's desk		
Box of mimeograph stencils		
Chalkboard eraser		
Calculator		
File cabinet		
Space under typing table		
Textbook		
Cash drawer compartment		
Classroom		
Packing box for a stove		

3. Supply the appropriate unit to make the sentence reasonable. Choose from mm^3, cm^3, dm^3, or m^3.

   a. The volume of an electric toaster is about 12 000 _____.

   b. A window air conditioner might cool about 49 _____ of room space.

   c. A four-cylinder foreign made compact car might have an engine size of about 2000 _____.

d. The amount of airspace in a classroom would be about 225 _____.

e. A bottle of water for the office cooler contains from 12 to 20 _____ of water.

f. An elevator shaft in a 3-story building might reasonably contain 36 _____ of space.

4. Remembering that it would take 1000 mm^3 to occupy the space of one cm^3, 1000 cm^3 blocks to occupy the space of one dm^3 and that 1000 dm^3 blocks fill one m^3, complete the following to make true statements.

a. 1500 m^3 = _____ cm^3

b. 2 m^3 = _____ dm^3

c. 500 cm^3 = _____ dm^3

d. 4000 cm^3 = _____ m^3

e. 5 cm^3 = _____ mm^3

f. 4000 dm^3 = _____ m^3

g. 0.42 dm^3 = _____ cm^3

h. 1.491 m^3 = _____ dm^3

i. 10 000 mm^3 = _____ cm^3

j. 0.1024 dm^3 = _____ cm^3

k. 186 321 cm^3 = _____ m^3

l. 144 mm^3 = _____ cm^3

m. 250 000 mm^3 = _____ dm^3

n. 144 dm^3 = _____ cm^3

o. 144 dm^3 = _____ m^3

p. 144 cm^3 = _____ mm^3

5. A packing box that is 1 dm wide, 2 dm long and 1.5 dm high has a volume of _____.

a. 4.5 dm^3 b. 3000 cm^3 c. 4.5 cm^3

6. A railroad boxcar is 15.4 m by 2.8 m by 3.2 m. Find the capacity of the car in cubic meters.

7. During a short coffee break a person consumed about _____ of coffee.

a. 0.35 m^3 b. 125 cm^3 c. 0.5 mm^3

8. The fluid container on a spirit duplicator holds about _____ of liquid.

a. 0.001 m^3 b. 0.001 mm^3 c. 22.4 dm^3

9. A salesman advertised a camping trailer whose drinking water compartment holds _____.

a. 40 dm^3 b. 40 cm^3 c. 40 mm^3

Liter Measure

The liter is not one of the basic SI units but it is a convenient unit and is used frequently enough that it has been accepted by the SI. The liter is just a little larger than a quart and will probably be used for small to moderately sized amounts. For large amounts it seems likely that the cubic meter will be the appropriate unit. So there are two alternatives for describing measures of volume or capacity—cubic measure and liter measure. There is no set rule stipulating which of the two measures should be used in a given situation. It seems to be simply a matter of custom and convenience.

Sales persons will see increasing use of metric units with the products they sell; for example, soft drinks by the liter, half-liter, and two-liter, and ice-cream packaged in 2-liter containers, etc. The sale of gasoline by the liter has been approved in California. Canned goods, now marked in ounces and liters, will be replaced by those marked in liters only.

One of the nice features of the metric system is the ease with which one may change from one unit of measure to another. This pertains to the interchange between cubic measure and liter measures as well. A liter container holds exactly the same amount as a cube one decimeter (10 cm) on each edge; that is, 1 L = 1 dm^3. Consequently, a 10-liter pail has a volume of 10 cubic decimeters, a 2-liter milk carton has a volume of two cubic decimeters, and a 1000-liter tank has a volume of 1 cubic meter.

Since a cube 10 centimeters on each edge contains 1000 cubic centimeters, each of these cubes is 0.001 of a cubic decimeter and hence is 0.001 of a liter. That is, one cubic centimeter equals one milliliter. In some areas, principally

in medicine, the cubic centimeter and the milliliter are constantly used interchangeably.

As with other metric units, it is important to develop a feel for the metric units of liter and milliliter. Classroom activities such as the following may help with this.

Suggested Activities

1. Estimate the capacity of each of these. Check your estimate by using water and a graduated cylinder to measure the capacities of small containers. Select some other containers familiar to you and learn their capacities.

Object	Estimated Size	Measured Size
Spirit duplicator fluid can		
Pop can		
Styrofoam cup		
Milk carton		
Serving spoon		
Catsup bottle		
Oil can		
Tempera paint jar		
India ink container		
_____		
_____		
_____		

2. Supply the appropriate unit to make the sentence reasonable. Choose from liter (L) or milliliter (mL).

   a. 30 _____ of Pepto-Bismol may be taken for upset stomach.

   b. Chocolate milk may be purchased in 2 _____ containers.

   c. Mary poured 100 _____ of syrup on her hotcakes.

   d. Ink for a mimeograph machine comes in a container that holds about 4 _____.

   e. Light machine oil is sold in 90 _____ cans.

f. With each restaurant order of spaghetti 25 _____ of parmesan cheese were provided.

3. Choose the best answer from those provided.

a. The capacity of a large mixing bowl is _____.

(1) 1500 mL (2) 40 L (3) 3 L

b. Some companies now distribute soda pop in _____ bottles.

(1) 2 mL (2) 10 L (3) 1000 mL

c. Styrofoam picnic cups contain about _____.

(1) 220 mL (2) 2.2 L (3) 0.75 L

d. Some ice cream cartons contain _____.

(1) 37.8 L (2) 3.78 L (3) 378 mL

The liter and milliliter are probably the only liter measures that will be used in practice. Conversions between liter and milliliter are done simply by remembering that

$$1000 \text{ mL} = 1 \text{ L}$$

$$1 \text{ mL} = 0.001 \text{ L}$$

For example, 258 mL = 258 x 0.001 L = 0.258 L.

4. Complete the following.

a. 1 liter = _____ mL

b. 2000 mL = _____ L

c. 20 000 mL = _____ L

d. 0.25 L = _____ mL

e. A 10-liter bucket holds _____ mL.

f. A box which measures 10 cm on each edge has a volume of 1 _____.

g. At 4 ^{o}C one liter of distilled water weighs 1 kilogram. At that temperature _____ mL would weigh 1 gram.

h. Fractional parts of a liter are expressed in decimal form. Thus 2½ liters would be written as 2.5 L which equals _____ mL.

5. Make the following conversions between cubic units and liter measures.

a. 18 cm^3 = _____ mL

b. 5 dm^3 = _____ L

c. _____ cm^3 = 250 mL

d. 18 L = _____ dm^3

e. 1.5 L = _____ m^3

f. 0.3 dm^3 = _____ mL

g. A box 2 cm by 3.5 cm by 10 cm has a volume = _____ = _____ mL.

6. If you poured a liter of liquid into a quart can would it overflow?

7. A station manager after measuring one of his gasoline tanks found it to contain 1800 liters of no-lead gasoline. During the next day these amounts of gasoline were sold from the tank: 20.4 L, 50.3 L, 41 L, 25 L, 62 L, 75.2 L, 9.8 L, 42.3 L, 17.1 L. At the end of the day how many liters of gasoline remained in the tank?

Mass

The terms mass and weight and their use have recently had considerable discussion. Mass is a quantity with an SI base unit and force is a quantity with an SI derived unit, but the term weight does not appear in SI. In science and engineering, however, the term weight has been used but a distinction between mass and weight has been carefully maintained. Currently, practices are being implemented (see Guidelines for Writers of SI Metric Standards, Appendix C) which will mean that the term weight will no longer be used in science and other technical fields. Instead, the term force of gravity will be used. In general everyday use, including the business occupations, no harm will occur by using the terms weight and mass synonymously.

A few metric units of mass are already used to some extent. Some canned goods and other products are available with contents designated in both customary and metric units. Large grain shipments are described in metric tons (not an SI unit); some medicine ingredients are given in milligrams. Nutritive amounts of protein, carbohydrates, fat, etc., shown on labels of food products and elsewhere are listed in grams. Vitamin content is given in milligrams.

Some abbreviations for metric units are in current use which do not conform to SI style practices. It is common to see the symbol gm, the abbreviation Gm., and other expressions for gram. The symbol g, however, is the proper SI symbol for gram. "Kilos" is sometimes used in reference to the mass of an object, particularly in athletic weight lifting events. This incorrect and misleading usage should be avoided.

The kilogram is about 2.2 pounds—a little heavier than a box of American processed cheese. The gram, only 0.001 of a kilogram, is the approximate mass of a paper clip, and the milligram is only 0.001 gram.

Suggested Activities

1. Supply the appropriate unit to make the sentence reasonable. Choose from kilogram (kg), gram (g), or milligram (mg).

   a. The mass of a candy bar is 40 _____.

   b. A golf tee has a mass of 1 _____.

   c. A piece of paper this size has a mass of 1 _____.

   d. A hobby store received a shipment of HO gauge railroad cars. The mass of the shipment was 30 _____.

   e. 150 mL of brewed coffee contains about 85 _____ of caffeine whereas 150 mL of decaffeinated coffee contains only about 3 _____ of caffeine.

2. Choose the best answer from those provided.

   a. A bottle of white correction fluid has a mass of

      (1) 300 mg (2) 50 g (3) 1 kg

   b. On a bill of lading, the mass of 46 boxes of circuit breakers was listed as _____.

      (1) 570 kg (2) 5.7 kg (3) 570 g

   c. The waybill for a shipment to a department store shows 180 cartons of window air conditioners with a total mass of _____.

      (1) 80 kg (2) 800 kg (3) 8090 kg

   d. The typewriting textbook has a mass of about _____.

      (1) 4.2 kg (2) 3000 mg (3) 1165 g

3. Estimate the mass of each of the following. Check your estimates by means of a balance or scale. Some objects you are often near; the masses of these you will want to remember.

Object	Estimated Mass	Measured Mass
Shorthand pad		
Billfold		
Ream of paper		
Pencil		
Calculator		
Nickel		
Chalk		
Textbook		
Paper cutter		
Eraser		
Electric stapler		
Typewriter		
_____		
_____		
_____		

Changing from one unit of mass to another in the metric system is easily done in the same way as with linear units. Knowing the meaning of each prefix is all that is required.

1 milligram = 0.001 gram 1 gram = 1000 milligrams

1 kilogram = 1000 grams 1 gram = 0.001 kilogram

4. Complete the following.

a. 750 g = _____ kg d. _____ g = 2.5 kg

b. 1450 g = _____ kg e. 1450 kg = _____ g

c. 500 mg = _____ g f. 10 g = _____ mg

5. How many 250 gram boxes of paper clips can be packaged from a carton containing 2 kilograms of paper clips?

6. At a price of 5 kg for $1.49, how many 5 kg bags of potatoes could one buy with $7.50?

7. If candy sells for $3.89 per kg, how much should be charged for 3.5 kg of this candy?

Volume--Mass

One of the nice features built into the metric system is the relationship between volume and mass. For several reasons water has been used to establish this relationship: 1 dm^3 of cold water has a mass of 1 kg. (To be exact, the water should be distilled and at a temperature of 4 °Celsius.) Thus, 5 dm^3 of water has a mass of 5 kg. Furthermore, because the specific density of all other substances is related to water it is easy to find the mass of any substance if the volume of the substance is known. For example, the density of steel is 8 times that of water so 1 dm^3 of steel has a mass of 8 kg; 2 dm^3 of steel has a mass of 16 kg; alcohol is only 0.84 times as dense as water so 1 dm^3 of alcohol has a mass of 0.84 kg, 2 dm^3 of alcohol has a mass of 1.68 kg, etc.

Since 1 dm^3 = 1 liter, 1 liter of cold water has a mass of 1 kg. Also, since 1 dm^3 = 1000 cm^3 = 1 L, 0.001 dm^3 = 1 cm^3 = 1 mL. So 1 cm^3 of cold water has a mass of 1 gram, and likewise, 1 mL of cold water has a mass of 1 gram. For larger volumes, observe that 1 m^3 = 1000 dm^3, so the mass of 1 m^3 of cold water is 1000 kg or 1 megagram.

Remember that this relationship is true for cold water--not for other substances. However, 1 dm^3 of most liquids would have a mass of approximately 1 kg.

Suggested Exercises

1. 6 mL of water has a mass of 6 _____.
2. 15 g of water would have a volume of _____ mL.
3. 250 g of water has a volume of _____.
4. _____ cm = 1 dm, so _____ cm^3 = 1 dm^3.
5. _____ dm = 1 m, so _____ dm^3 = 1 m^3.

6. 1 cm^3 of cold water has a _____ g mass.

7. 1 dm^3 of cold water has a mass of _____.

8. 1 m^3 of cold water has a mass of _____ kg.

9. The water in a tank 2 m by 1 m by 1.4 m has what mass?

10. In contrast to #9, try this one: The water in a tank 2 yds. by 1 yd. by 1.4 yds. weighs how much? (Hint: One cubic foot of water weighs about 62.5 pounds.)

It should be emphasized that the special volume-mass relationship in the metric system is restricted to volumes of cold water and their masses, not other substances. That is, a liter of cold water has a mass of 1 kg; a m^3 of cold water has a mass of 1000 kg; 1 milliliter of cold water has a mass of 1 gram.

To help with this understanding, the following experiment is suggested:

a. Take two containers, similarly constructed, each large enough to hold 1 liter.

b. Place the containers on opposite sides of a balance scale. Adjust the balance scale so that it balances properly. Fill one container with a liter of cold water and the other with a liter of sand. Are the scales now in balance? Does a liter of sand have a mass that is equal to, greater than, or less than a liter of cold water?

c. Repeat (b) above using a liter of salt or kitty litter.

d. Repeat using a liter of pop, milk or some other liquid. In these cases are the masses approximately equal to that of a liter of water?

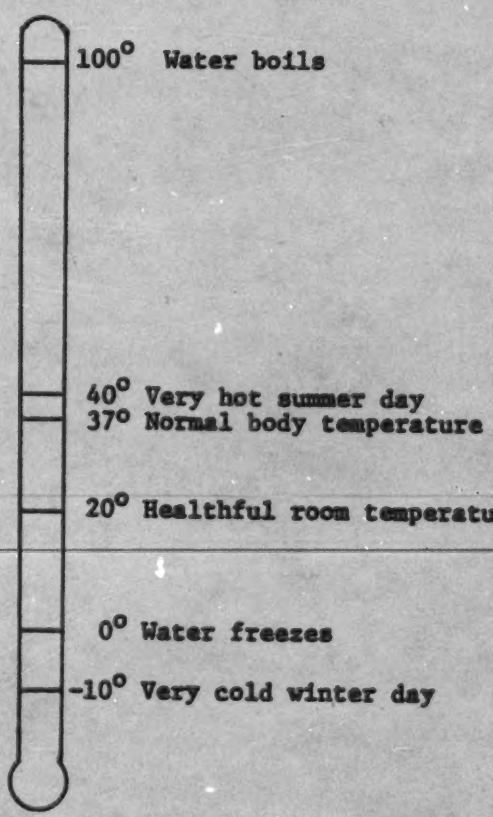
e. If the material is available, make a cube one decimeter on an edge out of cork or styrofoam. Compare the mass of this cube with that of a liter of water. (Caution: Be sure to compensate for the mass of the container holding the liter of water.)

Other Units

Several other metric units may be used to some extent in business occupations. A few of these are discussed here.

Temperature

The basic SI unit of temperature, the kelvin, will be used primarily in the sciences. Temperatures for most non-scientific work will be reported in degrees Celsius (^{o}C). This is not a basic SI unit but it has been accepted for use with SI units. The Celsius scale is named after the first man to use it and is identical to the centigrade scale which has been in use for many years. (The term centigrade, which also is an inclination measurement of 0.01 of a right angle, should no longer be used for temperature measurements.) A few Celsius temperatures are pictured below.


100° Water boils
40° Very hot summer day
37° Normal body temperature
20° Healthful room temperature
0° Water freezes
-10° Very cold winter day

Force

The SI unit of force is the newton (N). One newton is the force needed to give a mass of 1 kg an acceleration of 1 meter per second per second. In symbols this is expressed as: force (N) = mass (kg) x acceleration (m/s^2),

$$1\ N = 1\ kg \cdot m/s^2.$$

The newton is used when measuring the force needed to stretch a rubber band, to depress an automobile accelerator, to drag a box across the floor, to lift a baby, and when measuring the force of gravity. More specifically, the force needed to lift an apple is about 1 newton.

In the past, scientific and other technical use has differentiated between weight and mass. At the present time however, recommendations to the International Committee for Weights and Measures, and practices initiated by the American National Metric Council (ANMC) and the National Bureau of Standards (NBS) indicate that the term weight will be avoided in scientific and other technical fields. The term force of gravity will be used instead. In everyday activities the term weight may be used synonymously with mass.

The force of gravity on an object can be approximated if its mass is known. A kilogram mass exerts a downward force on the surface on which it rests. On earth the acceleration due to gravity is about 9.8 m/s^2, so the force exerted is 1 kg x 9.8 m/s^2 or 9.8 N. Roughly then, a 1 kg mass has a force of 10 N and the gravity force on a 250 gram hamburger is about 2.5 N.

Energy-Work

The metric unit of work, energy, and quantity of heat is the joule (J). Both work and energy are computed by multiplying force and distance. This product would be expressed in newton-meters (N·m). Torque is also the product of force and distance but is rotational rather than linear. To distinguish

between the linear and rotational action of the force involved, the joule is used as the unit of work and the newton-meter is reserved as the unit of torque.

In the customary system there are several units of energy but those most commonly used are the calorie, the kilocalorie ("large" calorie), kilowatt hour, and British Thermal Unit (BTU). The calorie is used primarily as a measure of heat energy and the large calorie is used for food energy. In the metric system (SI), the joule will be used for all measures of energy. Since the joule is rather small, the kilojoule (kJ) and megajoule (MJ) are likely to be used.

Listed below are the energy values for average servings of several different foods.

Food	Food Energy
Salted peanuts, 50 mL	736 J
Coleslaw, 120 mL	343 J
Orange sherbet, 120 mL	540 J
Donut, cake type	523 J

Examples of energy consumption are:

Refrigerator per day	18 MJ
Range per meal	5.4 MJ
Oven per hour	1.8 MJ
Toaster per slice	18 kJ
Iron per hour	3.6 MJ
Water heater per day	43.2 MJ
Color TV per hour	1.18 MJ
100 watt bulb per hour	360 kJ
Hair dryer per hour	1180 kJ

The energy usage of the items above is currently measured in kilowatt hours. The kilowatt hour is a measure of work which is accepted in the SI but its use should not be extended beyond the present uses. Instead the megajoule should be used. Note that 1 kwh = 3.6 MJ.

Miscellaneous Exercises

1. Most motor trucks and trailers have an interior width of _____.

   a. 200 mm b. 2 m c. 8 dm

2. How many square meters of carpeting are needed to cover a room 5 m by 3.4 m? If the carpeting costs $11.95 per square meter installed, find the cost for carpeting the room.

3. Vinyl floor tile is available in square tiles 30 cm on each side. How many tiles are needed to cover an aisle that is 18 m long and 2.1 m wide?

4. The length of a 4-door sedan is about _____.

   a. 22 cm b. 300 mm 5.8 m

5. The mass of a small car is about _____.

   a. 100 kg b. 2000 kg c. 1000 kg

6. Although rail freight may move quickly between terminals, long delays often occur in the railroad yard and reduce the average speed to _____.

   a. 88 km/hr. b. 5 km/hr. c. 30 km/hr.

7. Two liters of lemonade provide eight _____ mL servings.

8. On an automobile trip of 576 km, a traveler used 76 L of gas. The fuel consumption for this trip was _____ km/L.

9. A packet of sugar for a cup of coffee or tea contains about _____ of sugar.

   a. 4.5 kg b. 4.5 g c. 4.5 mg

10. A hardware store had several sales of screening during one day: 1.7 m, 0.8 m, 11.4 m, 0.5 m, 5.2 m, and 1 m. What was the total number of meters of screening sold? The total number of decimeters? If the screening was all 0.7 m wide, what was the total area of the screening?

Appendix A

The Supplementary Units

Unit	Quantity	SI Symbol
radian	plane angle	rad
steradian	solid angles	sr

The Derived Units with Special Names

Unit	Quantity	SI Symbol	Formula
newton	force	N	$m \cdot kg \cdot s^{-2}$
pascal	pressure	Pa	N/m^2
watt	power	W	J/s
joule	energy	J	N·m
coulomb	electric charge	C	A·s
farad	electric capacitance	F	C/V
henry	inductance	H	V·s/A
hertz	frequency	Hz	1/s or s^{-1}
lumen	luminous flux	lm	cd·sr
lux	illuminance	lx	lm/m^2
ohm	electrical resistance	Ω	V/A
siemens	conductance	S	A/V
tesla	magnetic flux density	T	Wb/m^2
volt	electric potential	V	W/A
weber	magnetic flux	Wb	V·s

The Derived Units without Special Names

Unit	Quantity	SI Symbol
square meter	area	m^2
cubic meter	volume	m^3
meter per second	linear velocity	m/s
radian per second	angular velocity	rad/s
meter per second squared	linear acceleration	m/s^2
radian per second squared	angular acceleration	rad/s^2
newton-meter	moment of force	N·m
kilogram per cubic meter	density	kg/m^3
joule per kelvin	entropy	J/K
watt per square meter	thermal flux density	W/m^2

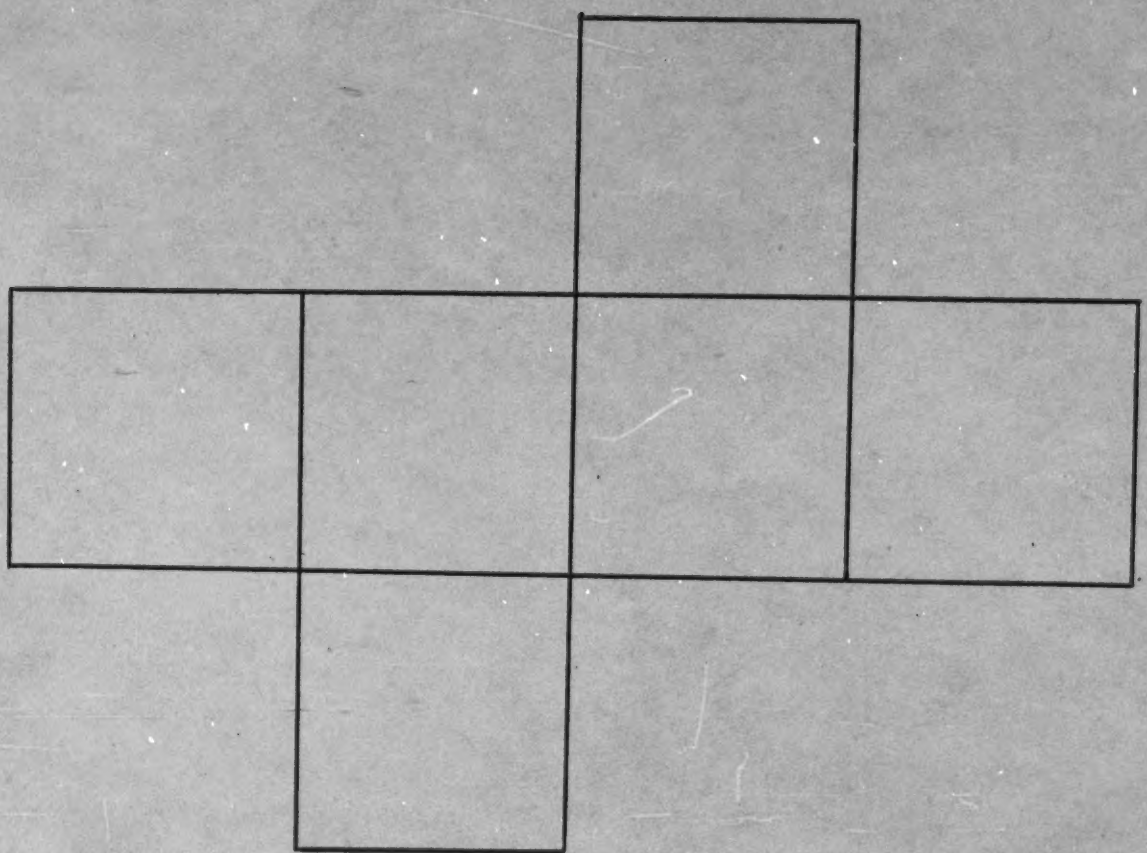
Prefixes

Names of multiples of SI and metric units are formed by using a prefix with "meter", "gram", "liter", "watt", or any other unit. Symbols use a prefix letter such as "ns" for nanosecond, "kHz" for kilohertz, "mV" for millivolt, etc.

giga	G	10^9	1 000 000 000	one billion
mega	M	10^6	1 000 000	one million
kilo	k	10^3	1 000	one thousand
hecto	h	10^2	100	one hundred
deka	da	10^1	10	ten
—	—	10^0	1	one
deci	d	10^{-1}	0.1	one tenth
centi	c	10^{-2}	0.01	one hundredth
milli	m	10^{-3}	0.001	one thousandth
micro	μ	10^{-6}	0.000 001	one millionth
nano	n	10^{-9}	0.000 000 001	one billionth
pico	p	10^{-12}	0.000 000 000 001	one trillionth

Appendix B

Suggested Diagram for Paper Cubes



Appendix C

Sources of Information

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Metric Practice Guide and Style Manual, National Bureau of Standards, from AMJ Publishing Company, Tarzana, California 91356.

Metric Guide for Educational Materials, American National Metric Council, 1625 Massachusetts Avenue, N.W., Washington, D.C. 20036.

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American Metric Journal. Published bimonthly by AMJ Publishing Company, P.O. Box 696, Tarzana, California 91356.

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Metric Reporter. Published biweekly by the American National Metric Council, 1625 Massachusetts Avenue, N.W., Washington, D.C. 20036.

Metric News. Published bimonthly by Metric News, Inc., 830 North 109th Street, Milwaukee, Wisconsin 53226.

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The Metric Manual, The Bureau of Business Practice, Waterford, Connecticut 06386.

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The Teacher's Guide to the Metric System, A. L. LeMaraic and J. P. Ciaremella, Metric Media Book Publishers, P.O. Box 266, Somers, New York 10589.

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Appendix D

Standards Committees

ISO—The International Organization for Standards is an international, non-governmental agency for standards which is comprised of national standards bodies of about 80 nations.

ANSI—The American National Standards Institute is a federation of some 180 trade associations, technical societies, labor unions, and about 900 company members. ANSI is the U. S. member of ISO. ANSI does not write standards. It reviews and approves proposed standards written by committees administered by many technical and trade associations after all concerned groups have accepted them.

The address for ANSI is 1430 Broadway, New York, New York 10018. Current information about developments within specific trade associations is found in journals such as:

Metric News. Published bimonthly by Metric News, Inc., 830 North 109th Street, Milwaukee, Wisconsin 53226.

Metric Bulletin. Published monthly by J. J. Keller and Associates, Inc., 145 W. Wisconsin Avenue, Neenah, Wisconsin 54956.

Metric Reporter. Published biweekly by the American National Metric Council, 1625 Massachusetts Avenue, N.W., Washington, D.C. 20036.

American Metric Journal. Published bimonthly by AMJ Publishing Company, P.O. Box 696, Tarzana, California 91356.

Answers

Pages 16-18

4. a. mm
   b. cm
   c. dm
   d. cm
   e. m; m
   f. cm
   g. mm
   h. km
   i. mm; m

5. a. 2.5 cm
   b. 1.4 m
   c. 38 cm
   d. 210 by 297 mm
   e. 5000 km
   f. 2 mm
   g. 2.8 m
   h. 0.3–0.9 mm

6. a. 5600
   b. 5.6
   c. 3200
   d. 280
   e. 0.28
   f. 8
   g. 6.35; 635
   h. 5.8; 0.058
   i. 139
   j. $2\frac{17}{36}$; 89

7. $48.00

8. cm; cm

9. $14.47

Pages 20-23

3.

Region	Calculated Area	Region	Calculated Area
1	8 cm^2	4	9.6 cm^2
2	8 cm^2	5	12.6 cm^2
3	57 cm^2		

6. a. cm^2
   b. cm^2
   c. m^2
   d. cm^2
   e. cm^2
   f. cm^2

7. a. 20 m^2
   b. 48 cm^2
   c. 28.8 m^2
   d. 209 m^2
   e. 175 000 m^2
   f. 88 920 m^2

8. a. 7400 cm^2
   b. 60 000 cm^2
   c. 1050 cm^2
   d. 616 cm^2
   e. 21 m^2
   f. 0.295 m^2
   g. 4.062 5 m^2
   h. 60 m^2

9. 4900; 9800

10. a. 0.45
    b. 15
    c. 1
    d. 2

11. a. 30 000
    b. 0.5
    c. 500
    d. 2.5
    e. 4
    f. 500

12. 3.6

13. 270; 2.7

14. About 4.63

15. About 3.86

16. 600

17. a. 2200 cm^2
    b. 15 m^2
    c. 2500 cm^2
    d. 6700 cm^2

Pages 26-28

3. a. cm^3
   b. m^3
   c. cm^3
   d. m^3
   e. dm^3
   f. m^3

4. a. 0.0015
   b. 2000
   c. 0.5
   d. 0.004
   e. 5000
   f. 4
   g. 420
   h. 1491
   i. 10
   j. 102.4
   k. 0.186 321
   l. 0.144
   m. 0.25
   n. 144 000
   o. 0.144
   p. 144 000

5. 3000 cm^3
6. About 138 m^3
7. 125 cm^3
8. 0.001 m^3
9. 40 dm^3

Pages 29-31

2. a. mL
   b. L
   c. mL
   d. L
   e. mL
   f. mL

3. a. 3 L
   b. 1000 mL
   c. 220 mL
   d. 3.78 L

4. a. 1000
   b. 2
   c. 20
   d. 250
   e. 10 000
   f. L
   g. 1
   h. 2500

5. a. 18
   b. 5
   c. 250
   d. 18
   e. 0.0015
   f. 300
   g. 70 cm^3; 70

6. Yes

7. 1456.9

Pages 33-34

1. a. g
   b. g
   c. mg
   d. kg
   e. mg; mg

2. a. 50 g
   b. 570 kg
   c. 8090 kg
   d. 1165 g

4. a. 0.750
   b. 1.45
   c. 0.5
   d. 2500
   e. 1 450 000
   f. 10 000

5. 8

6. 5

7. $13.62

Pages 35-36

1. g
2. 15
3. 250 mL
4. 10; 1000
5. 10; 1000
6. 1
7. 1 kg
8. 1000
9. 2800 kg
10. About 4725 pounds

Page 41

1. 2 m
2. 17; $203.15
3. 420
4. 5.8 m
5. 1000 kg
6. 30 km/hr
7. 250
8. 7.6
9. 4.5 g
10. 20.6; 206; 14.42 m^2 or 1442 dm^2